REMARKS/ARGUMENTS

Claims 1-30 are pending herein, claims 1 and 26 being independent. By the amendment above, claim 1 has been amended to incorporate therein the limitations of claim 4, which has been canceled, and claims 2, 3 and 5-30 have been amended in purely cosmetic fashion. A new dependent claim 31 has been added, depending from claim 1. No new matter has been added. Support for the subject matter of claim 31 may be found in the specification, *e.g.*, at page 7, lines 22-25.

Initially, it is pointed out that Patent No. 6,513,577 was issued from the subject patent application on February 4, 2003. Prior to the issuance of the patent, applicant submitted an Information Disclosure Statement dated May 20, 2002 which cited U.S. Patent No. 6,000,438 (Ohrn). By fax dated June 27, 2002, the Examiner provided applicant with a signed form 1449 indicating that the Ohrn reference was considered. Thereafter, the patent issued and was then withdrawn by way of the current Office Action which relies on Ohrn in rejecting the claims. In view of this prosecution history, it is respectfully requested that the Examiner handle this Amendment on an expedited basis so that the patent can, again, be issued.

In the pending Action, the Examiner rejected claims 1-4, 6, 11, 12, 26 and 30 under 35 U.S.C. § 102(e) as anticipated by United States Patent No. 6,000,438 (Ohrn); and rejected claims 10, 14, 15 and 29 under 35 U.S.C. § 103(a) as allegedly obvious over Ohrn in view of United States Patent No. 6,058,979 (Watkins). The Examiner then objected to claims 5, 7-9, 13, 16-25, 27 and 28 as depending from a rejected base claim, but indicated that such claims presented allowable subject matter and would be allowed if re-written in independent form.

The applicants have carefully considered the Examiner's rejections and objections, and respectfully submit that all of the claims present allowable subject matter. Accordingly, for the

reasons set forth below, it is respectfully requested that the pending rejections be withdrawn, and the claims be allowed to issue as amended.

The present invention is directed to apparatus (claims 1-3, 5-25, and 29-31) and methods (claims 26-28) using a liquid/solid phase change material ("PCM") for insulating offshore subsea oil pipelines. In the present invention, an underwater pipe is surrounded by an insulating coating comprising a PCM, the insulating coating being protected by a protective envelope which is resistant and *deformable* to take into account the variation of volume due to the combination of the physical properties of the insulation medium:

- compressibility;
- thermal expansion; and
- variation of volume of the PCM at phase change (liquid/solid).

This variation of volume at phase change is the main concern of this technology, as PCMs may vary in volume by up to 10 to 20%.

To get an insulation complex which remains stable during the lifetime of the pipeline in ultra-deep waters, the space between an internal pipeline and an external jacket casing is fully filled by the insulation coating, with no voids being created upon completion of the process, as well as during the life duration of the pipeline on the seabed. Therefore, the present invention relates to the combination of the use of a PCM together with a *deformable* protective envelope.

According to the claimed invention the PCM can be used for insulating underwater pipe at great depth (*i.e.*, at least 300 m) because it is protected by a *deformable* and resistant outer envelope. When there is a variation in volume in the PCM caused by a variation in temperature, the deformable protective envelope follows the variation in volume of the insulating coating. The

pressure in the insulation complex matrix corresponds to the pressure at the depth at which the pipeline is situated.

In the preferred embodiment of the present invention recited in claim 2, the PCM is absorbed in an absorbent matrix which surrounds the underwater pipe. When the PCM is absorbed in an absorbent matrix surrounding the inner pipe, the PCM can be advantageously poured directly in the absorbent matrix and therefore it is disposed uniformly around the inner pipe.

Moreover, when the PCM absorbed in the absorbent matrix is at room temperature upon completion of the manufacturing process, or when put in the water and laid on the seabed, the decrease of temperature creates a solidification and rigidification of the PCM at its periphery, so that the protective envelope abutting the rigid PCM material is able to support the weight of the pipe.

It is respectfully submitted that the use of a deformable and resistant outer envelope has neither been disclosed nor suggested in the Ohrn reference applied by the Examiner.

The capacity of the inventive device to be deformable is advantageous for insulating an underwater pipe at great depth *i.e.* below 300 meters and even up to 3,000 meters and beyond, the complete insulation medium being submitted to the pressure at said depth (about 30 Mpa @ 3000 m water depth).

Ohrn discloses a different apparatus. Ohrn teaches the use of a PCM as an insulation coating for undersea pipes. Ohrn does not teach surrounding the underwater pipe with a *deformable* envelope as is required by claim 1.

Ohrn discloses two embodiments for carrying out the insulation of underwater pipe with a PCM.

The first embodiment is disclosed in column 3, lines 14 to 26, wherein the PCM is contained between 2 pipes *i.e.* in a pipe-in-pipe configuration. The PCM is directly poured in a liquid state

between the two *rigid* pipes to fill the annular region between the inner carrier pipe 12 and the outer jacket pipe 14. Accordingly, the outer jacket 14 is a pipe, *i.e.*, resistant and *rigid*, and therefore not a *deformable* jacket. This first embodiment is therefore not suitable for use at great depths, and displays a significant shortcoming when used for insulating an underwater pipe at great depth. Specifically, the exterior hydrostatic pressure is very important and therefore it is necessary that the PCM fills the region between the two pipes to resist the high pressure and avoid implosion of the outer envelope. However, as explained in the present specification, the PCM material, and especially paraffin, is subject to a considerable variation in volume during the change of state, which may reach as much as 20% in the case of paraffin. Therefore, at the end of the manufacturing process, when the pouring of insulation material is completed and the temperature returns to room temperature, the insulation retracts, creating voids. In a rigid pipe as shown in Ohrn, these voids usually appear in locations where insulation is still liquid or pasty, namely, adjacent to locations where insulation is solid, thereby creating a suction effect and then a vacuum. The complete insulation material, liquid-pasty-solid is then subject to this vacuum for degassing, which will be most effective in the zones of highest temperature, *i.e.*, in liquid-state zones.

The insulation material trapped between the two rigid circular casings described by Ohrn will then be subject to the creation of voids as well as the longitudinal migration of insulation material where cold points exist along the insulated pipe, especially when the insulated pipe line is laid on the seabed at great depth.

In practice, then, the insulation will not uniformly surround the inner carrier. The phenomenon of longitudinal migration, after several cycles of liquefaction-solidification of the PCM insulation medium, creates the risk of uncontrolled local cold points, and such cold points risk the creation of blockage in flow by the formation of hydrates or paraffin in the pipeline.

In addition, to avoid damages by implosion of the external jacket, the external jacket must have considerable resistance (*i.e.*, be very thick) to keep its circular shape when subjected to the high hydrostatic pressure corresponding to a water depth of more than 1000 meters.

Ohrn's second embodiment is disclosed in column 3, lines 36 to 46. There, it is described that the PCM is a microencapsulated PCM dispersed within a conventional insulating material. Conventional insulation materials are constituted either

a) of polypropylene or polyurethane foams; or
b) of a syntactic material (column 4 lines 46-52).

In the second embodiment, the use of an outer jacket pipe 14 is unnecessary (column 3, lines 33-35; and column 4, lines 14-16). Accordingly, this second embodiment is not suitable for using PCM insulation at great depth.

Polypropylene or polyurethane foams display insulating properties because they contain voids--cells filled with air or other gases, usually at ambient pressure, *i.e.* within 0.1 Mpa, preferably at reduced pressure, or even better under vacuum. Such foams are usually closed cell foams, and when they are subjected to pressure, this pressure damages the foam structure. The cells collapse and the insulation material loses its insulating properties. Therefore, such insulating materials must necessarily be protected by a rigid outer pipe to maintain their insulating properties. As a result, when the volume of the PCM decreases due to a change from liquid state to solid state, the above-mentioned risk of damages by implosion of the rigid pipe at great depth still exists.

Syntactic foam is made of a rigid epoxy as binding agent including hollow glass microspheres as explained in the present specification. Syntactic foams are capable of withstanding high hydrostatic pressure, and therefore are suitable for insulation of pipes at great depth. However, syntactic foams are not tight, and therefore when the PCM changes from liquid to solid and when the volume of the PCM decreases, gas or water may penetrate inside the syntactic foam.

Later, when the hot oil circulates inside the inner pipe, the rise in temperature causes the volume of the PCM to expand. This expansion causes a buildup of pressure inside the syntactic material, which crush by implosion the glass microspheres located in the vicinity, and therefore the syntactic foam would lose its insulation properties. This phenomenon will amplify at each cycle of liquefaction-solidification, that is to say at each shut down of the flowline. As a consequence, this second embodiment is not suitable for carrying out pipe insulation with PCM at great depth where the hydrostatic pressure is very high. Accordingly, for these reasons, it appears that the use of a deformable outer envelope is neither disclosed nor suggested by Ohrn, and is not even contemplated by Ohrn, since it is never mentioned therein.

Thus, the claims are patentably distinct from the disclosure of Ohrn.

Additionally, the characteristics of claim 2 (wherein the PCM is impregnated in an absorbent matrix) have also not been disclosed nor suggested in Ohrn.

Indeed, it is respectfully submitted that in the device described by Ohrn, the PCM insulating material may be surrounded by the above mentioned rigid conventional insulating foam (see column 4, lines 1-2 and lines 46-52). However, it is never disclosed nor suggested to have the PCM insulating material impregnated in a fibrous absorbent matrix surrounding the pipe.

Accordingly, it is respectfully submitted that the rejection under 35 USC § 102 of the above mentioned claims is not well-founded and should be withdrawn.

The addition of Watkins overcomes none of the shortcomings of Ohrn. The Examiner has submitted that Ohrn discloses all of the claim limitations except for the protective envelope being made of a thermoplastic material. But the Examiner further contends that, given the teaching of Watkins including a protective cover made of a thermoplastic material, it would have been obvious

to one of ordinary skill in the art at the time of the invention to modify the outer protective pipe of Ohrn with a protective envelope made of thermoplastic material. Applicants respectfully disagree.

Watkins teaches the use of an insulating material for a deep sea pipe comprising macrospheres surrounded by syntactic foam. Such insulating material provides sufficient strength to withstand the hydrostatic pressure at great depth and therefore does not display the important volume variation of the PCM insulating material of the present invention. This is the reason why it is mentioned in Watkins (see column 2, lines 20-24) that the protective outer casing is <u>optional</u> and may be a plastic pipe. This is the same teaching as in the Ohrn reference. Therefore Watkins does not suggest render obvious (taken alone or in combination with Ohrn) use of a deformable envelope around a PCM insulating material as claimed in claim 1.

More importantly, it is submitted that modifying the outer protective pipe of Ohrn with a protective envelope made of thermoplastic material would not lead to the claimed invention, because in the device taught by Ohrn, PCM is encapsulated and dispersed in conventional insulating foam or in an insulating syntactic foam, and therefore the insulating coating would not be subjected to variations in volume.

For all these reasons, therefore, it is respectfully submitted that the invention as claimed is patentably distinct from the references applied by the Examiner, taken alone or in combination. Accordingly, it is respectfully submitted that these rejections and objections should be withdrawn, and the application permitted to issue.

There being no further grounds for rejection or objection, early and favorable action is respectfully solicited.

It is believed that no fees or charges are required at this time in connection with the present application. However, if any fees or charges are required at this time, they may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,

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By [signature]

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